High Energy Novel Cathode / Alloy Automotive Cell

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Project ID #
ES131

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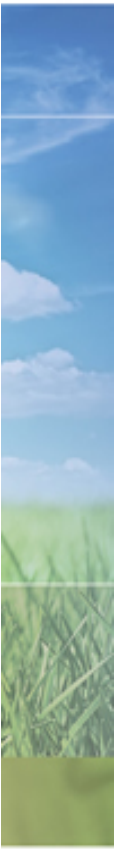
Overview



- Timeline
  - *start: 10/01/2011*
  - *finish: 1/15/2015*
  - *~42% complete*
- Budget
  - *Total project funding*
  - *DOE share: $4,577,909*
  - *Contractor share: $1,961,961*
  - *Funding received in FY11: $ 0*
  - *Funding for FY12 : $1,700,000*
  - *Funding for FY13 : ~$1,700,000*
- Barriers
  - *Cycle Life, Energy, Cost and Thermal Stability*
- Targets
  - *Increase in energy density > 40%*
  - *Reduce Cost > 25 %*
  - *Maintain thermal stability and cycle life*
- Partners
  - *Argonne National Laboratory*
  - *Dalhousie University*

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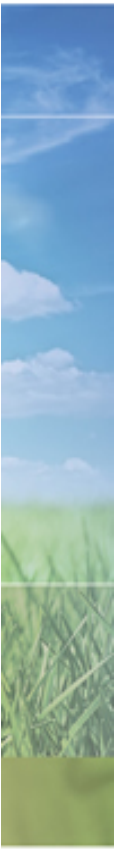
Project Objectives



To develop a high-performance battery cell for electrical vehicle with high energy density and low cost by integrating advanced chemistries

- *at least 40% (1.4X base Wh/l) increase in energy density compared to baseline cell performance (NMC111 and Graphite)*
- *35% increase in energy for advanced high voltage cathode*
- *70% increase in volumetric capacity for alloy anode*
- *at least 25% lower cost per unit energy at cell level for a comparative integrated advanced materials cell to a baseline materials one*

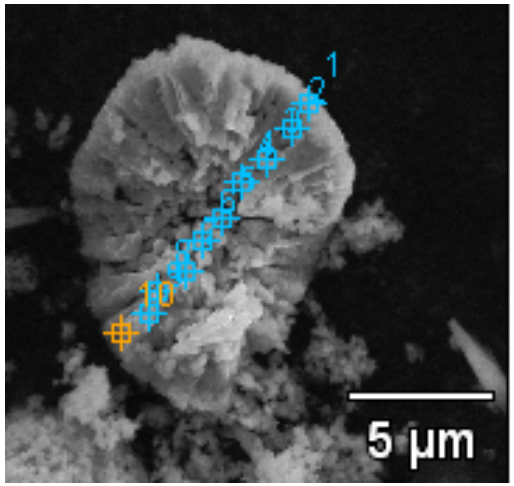
Milestones

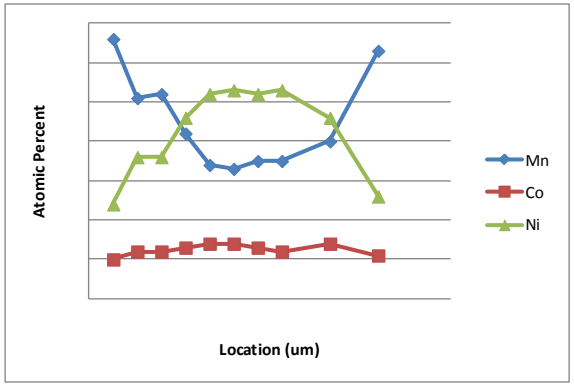
Month/Year	Milestone or Go/No-Go decision
Apr-12	**Milestone** : Complete the synthesis of advanced materials in quantities to build cells
July-12	**Milestone** : Complete the prototype large cell build with baseline material
Sep-12	**Milestone**: ▪Finalized 18650 as the relevant format ▪Demonstrated advanced materials capability to meet targets ▪Demonstrated baseline materials performance per EV test protocol
Sep-13	**Milestone**: ▪Electrode coating procedures for advanced materials ▪Baseline materials data package ▪Preliminary 18650 with advanced materials to meet program goals

Approach - High Energy NMC Cathode Development

Core-Shell Concept

- *High Mn Shell: Cycle-Life*
- *High Ni Core: Capacity*
- *Combined: Stable High Energy*

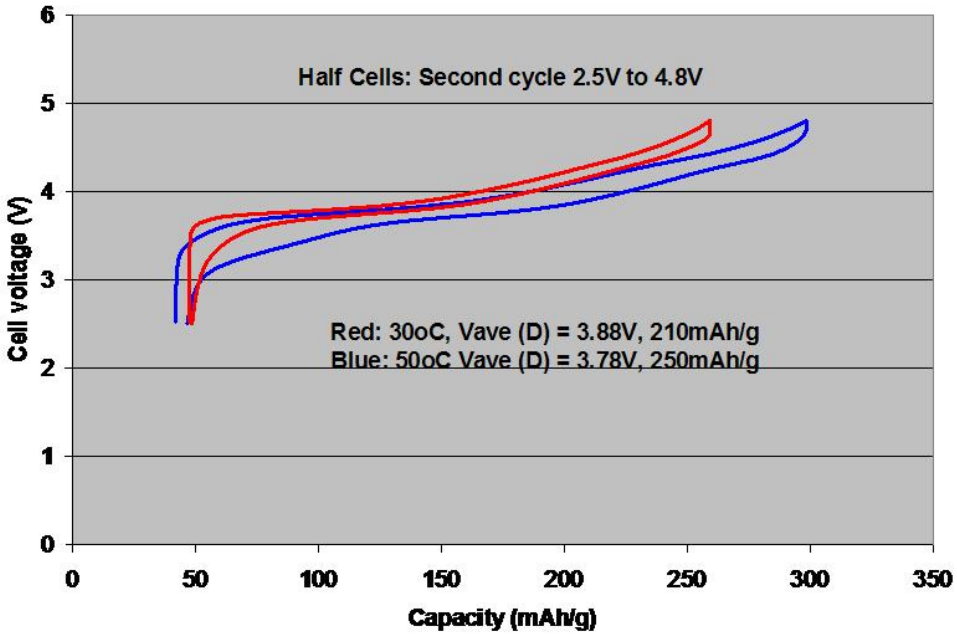


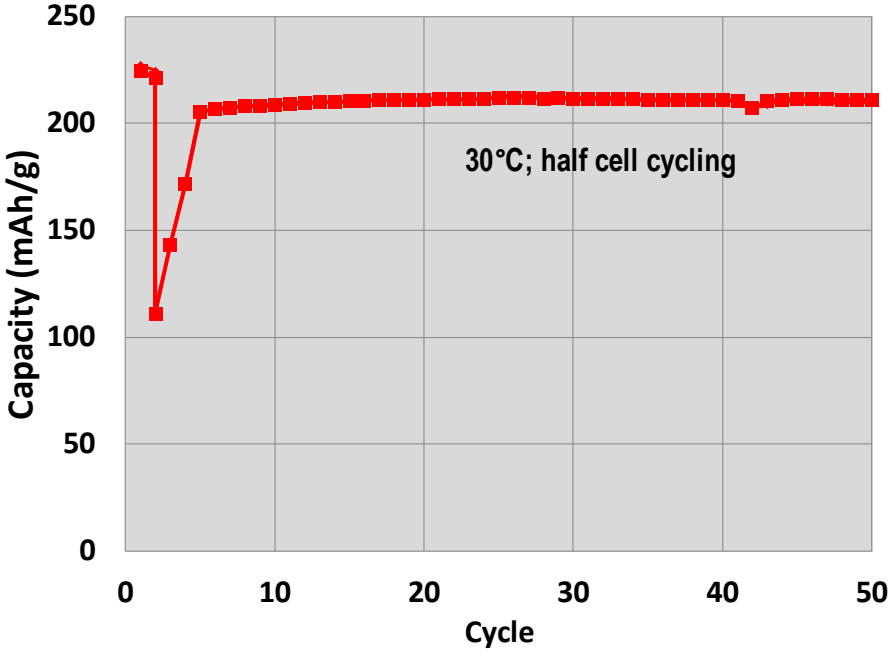


	Oxide	Capacity	X	Density	X	Voltage	X	Irrev Factor	=	Cathode Energy Factor
Electronics	LCO	1.79		3.75		3.99		0.95		25.4 (graphite)
	LCO	1.79		3.75		3.99		0.88		23.6 (alloy)
	NCA	1.96		3.5		3.78		0.97		25.1 (graphite)
Automotive	NMC	1.60		3.3		3.90		0.98		20.1 (graphite)
	NMC	1.60		3.3		3.90		0.95		19.6 (alloy)
Core-Shell	126M	2.30		3.4		3.84		0.95		28.5 (alloy)
	126T	2.20		3.4		3.88		1.00		29.0 (alloy)

Accomplishment - Viable High Energy NMC Cathode

Material validation in half cell (vs. Li)





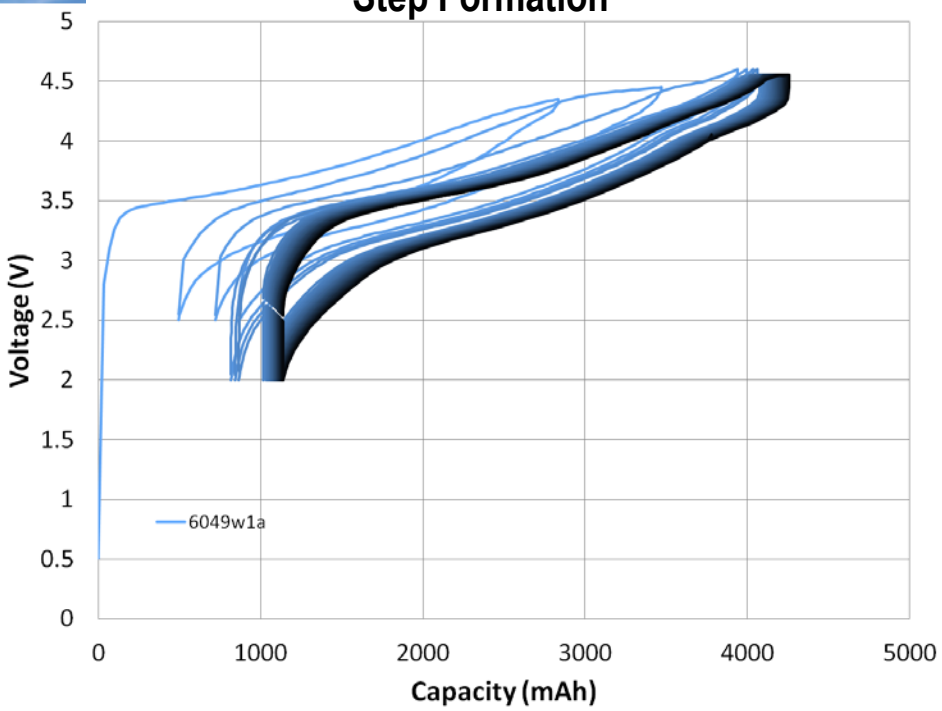
High Average Voltage; Excellent Rate Capability; Standard Electrolyte Stability; Matched to Si Anode

Accomplishment - Stable Voltage Curve

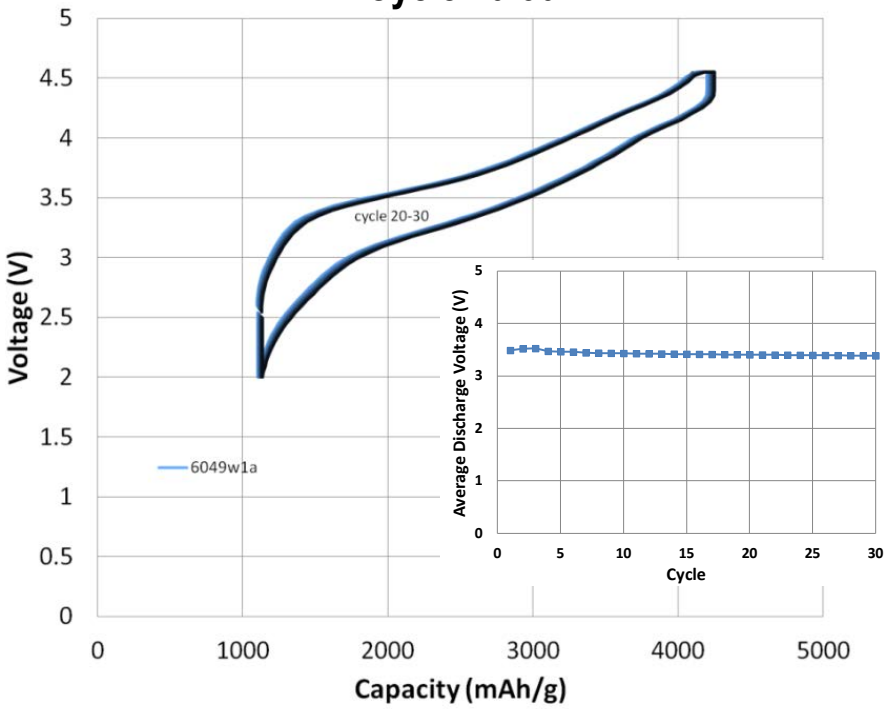
18650 Test Data;

Anode: 3M alloy / graphite composite; Cathode: High Energy NMC Cathode

Step Formation



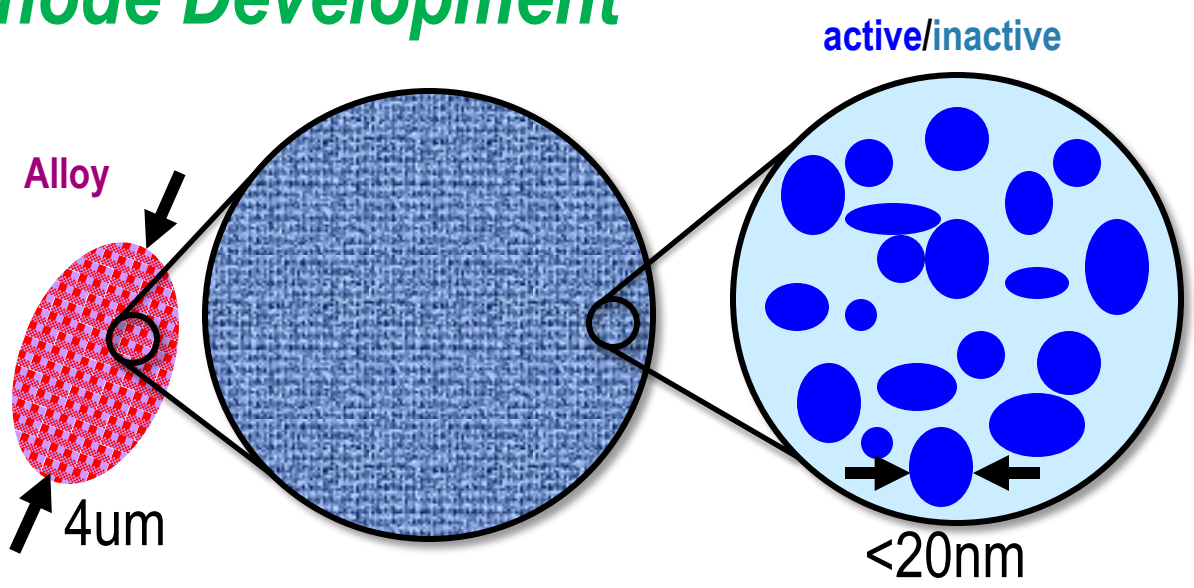
Cycle 20-30

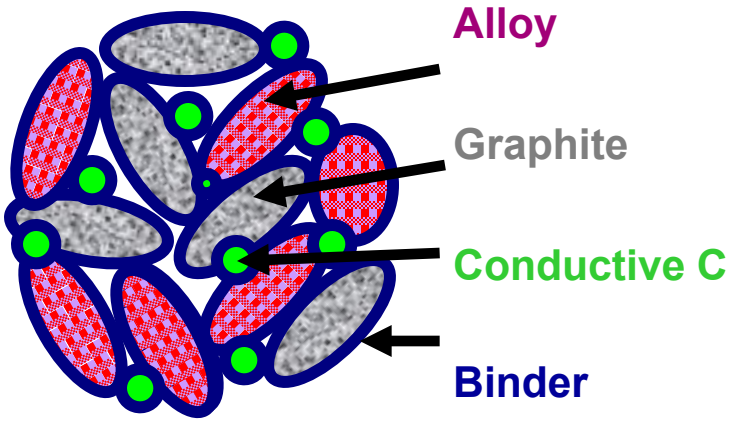


Stable voltage curve than pure O_2 loss cathode

Approach - Si Anode Development

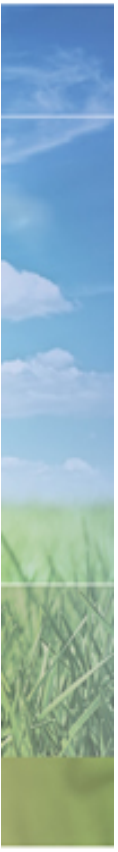
- Alloy Level
  - *Composition*
  - *Microstructure*
- Electrode Level
  - *Graphite*
  - *Conductive Carbon*
  - *Binder*
  - *Dispersion Quality*
- Cell Level
  - *Matching Cathode*
  - *Electrolyte*

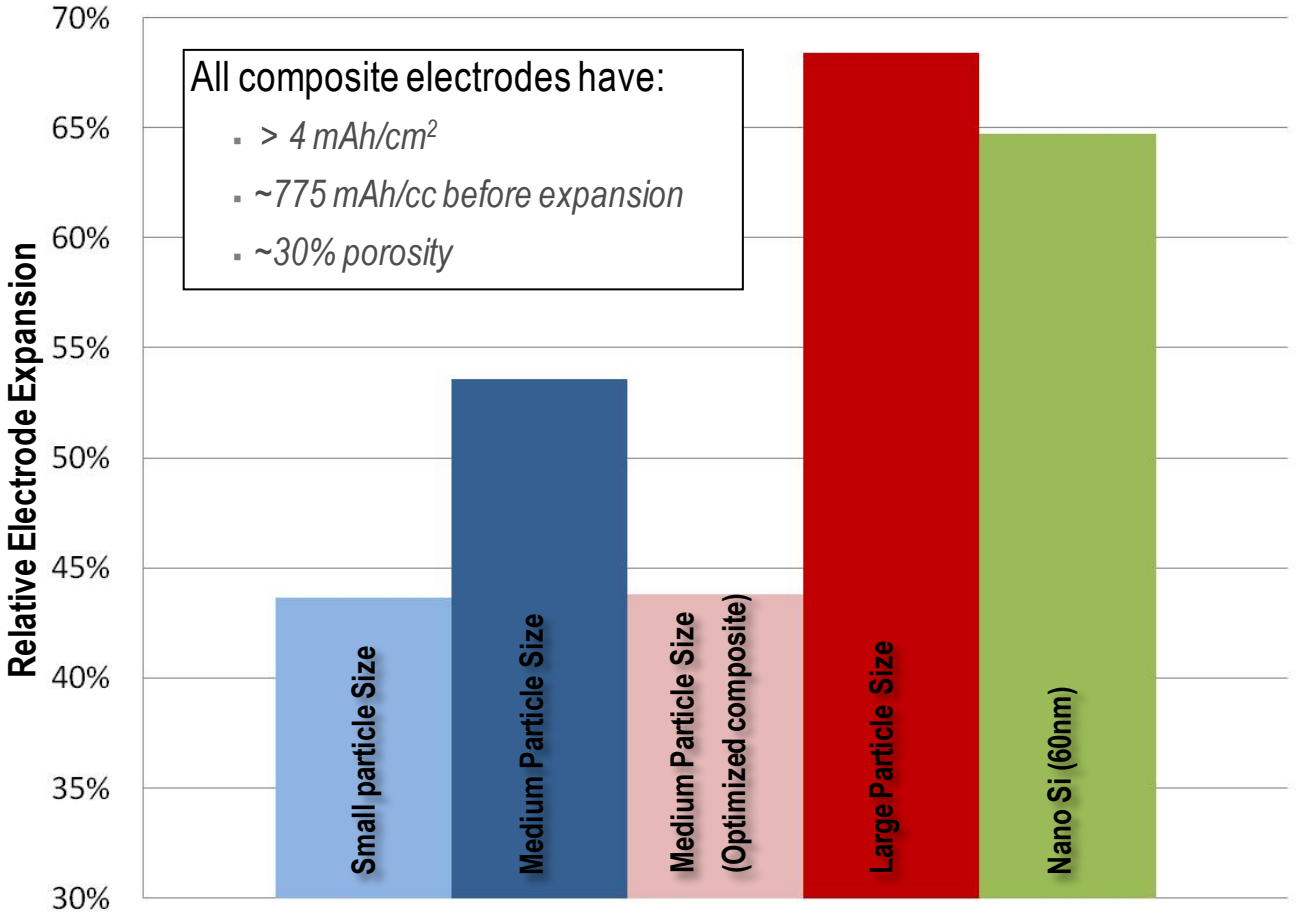




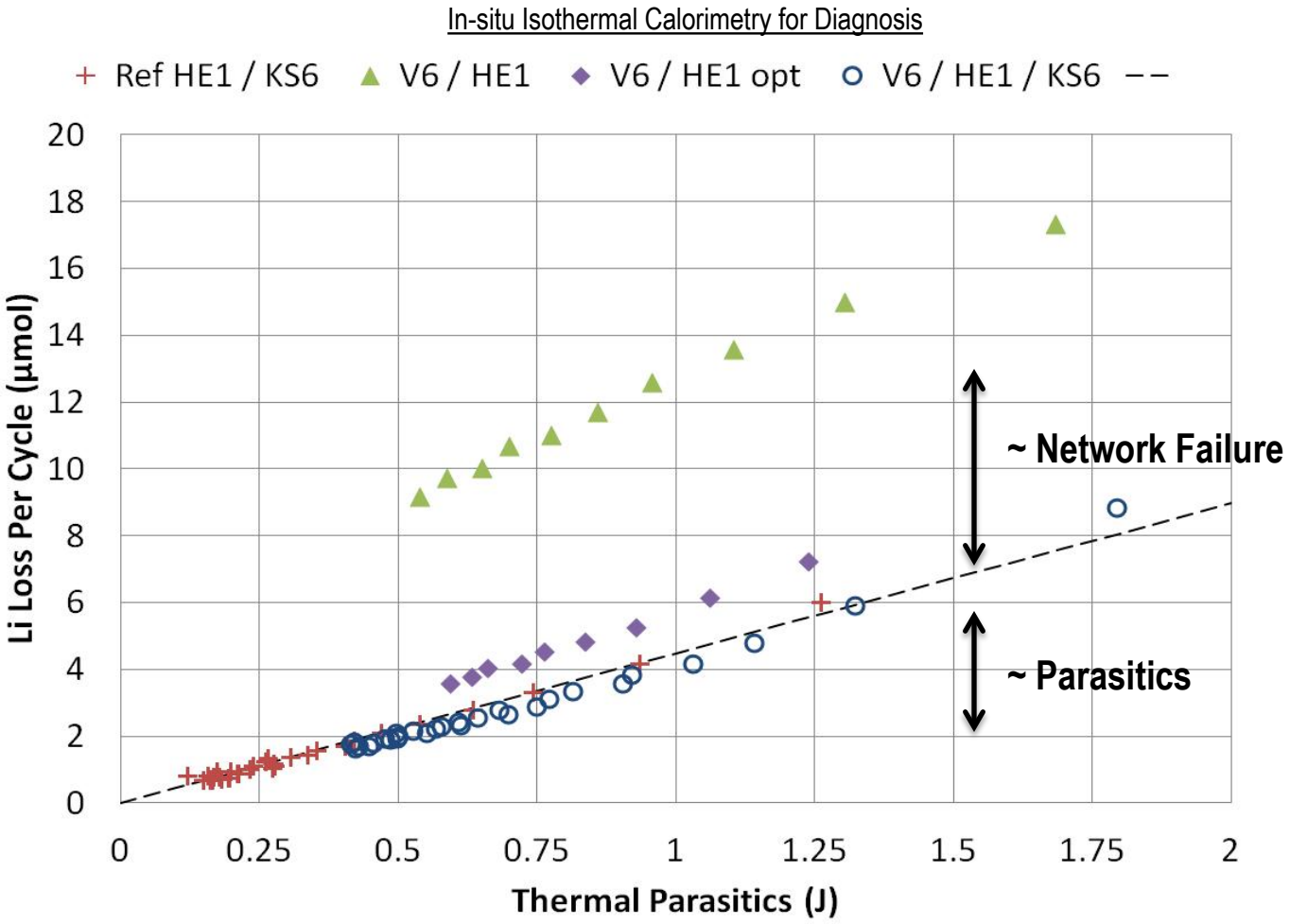
Multi-facet approach to optimize energy, cycle-life and composite thickness

Accomplishment – Reduce Electrode Expansion



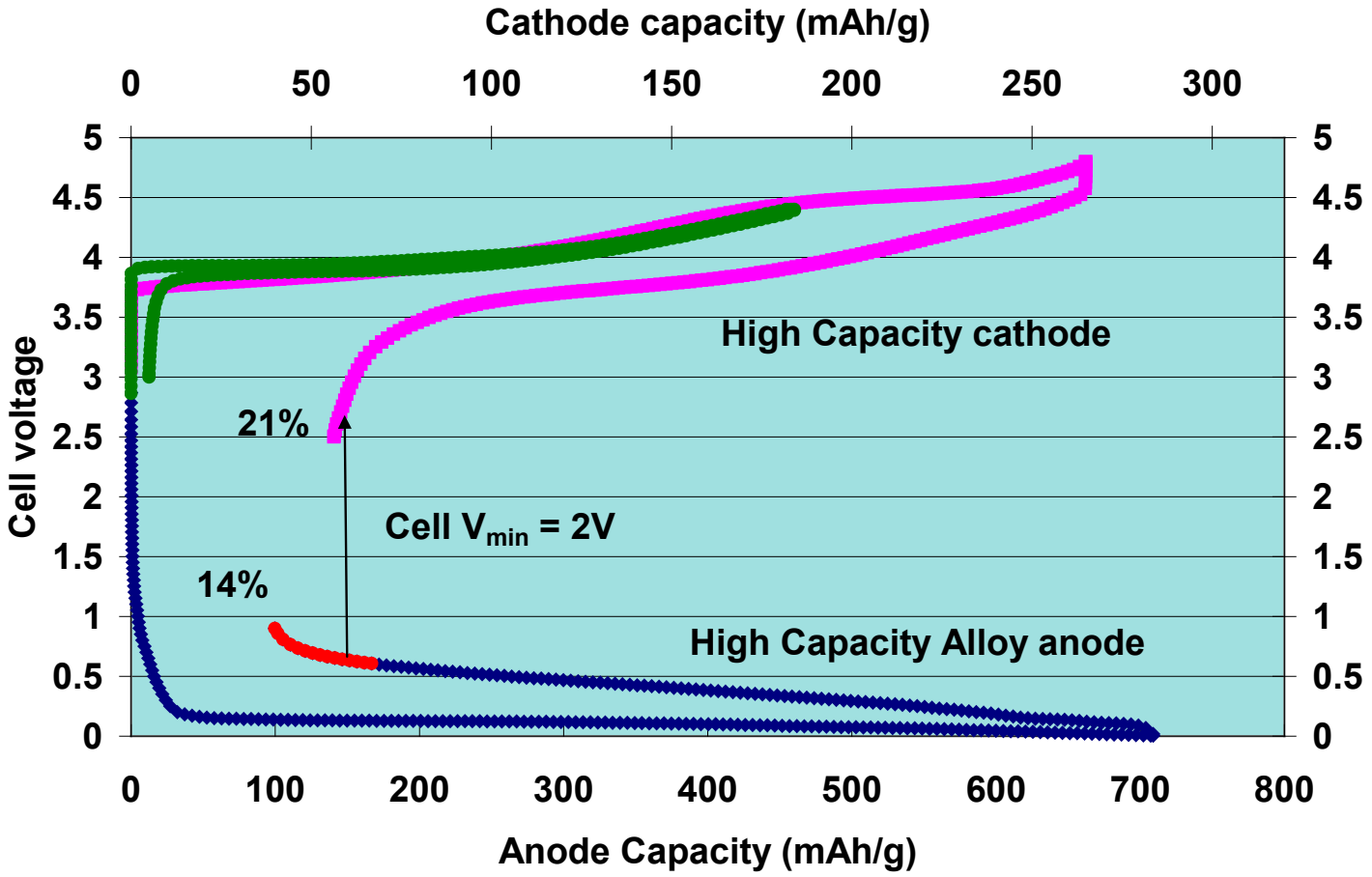


Accomplishment - Rational Si Electrode Optimization



Including KS6 flake graphite overcomes electrical network failure.

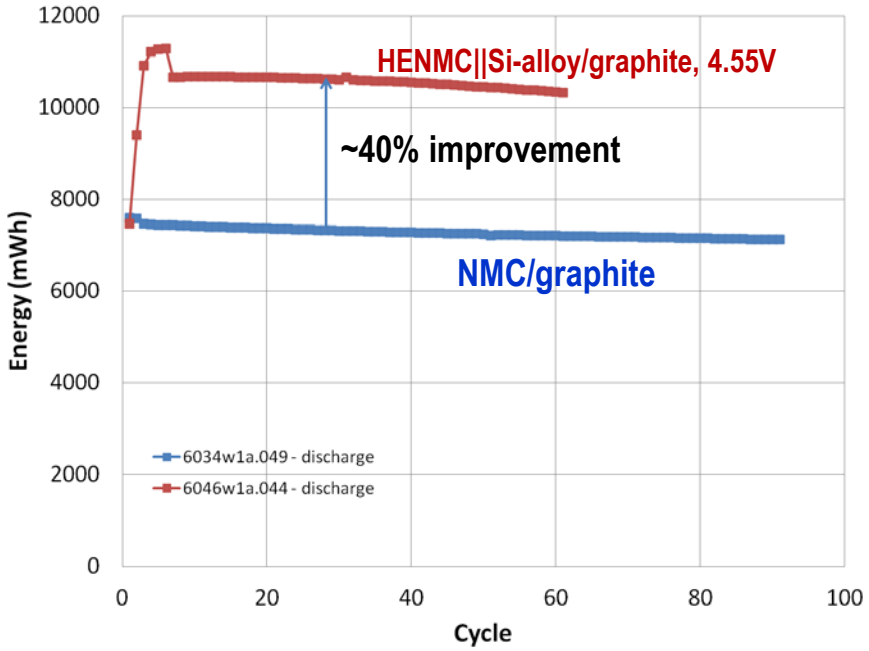
Approach - Cell Integration (HE NMC // Si)



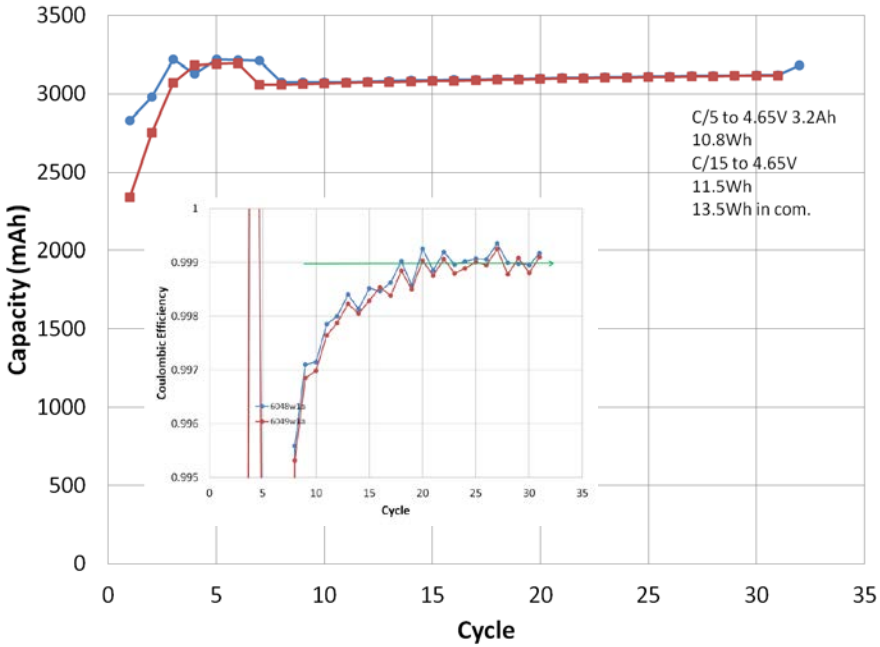
Matching 1st cycle efficiency maximizes benefit of both materials

Accomplishment - 18650 Energy Improvement

Same 18650 design



Cycling to 4.65V

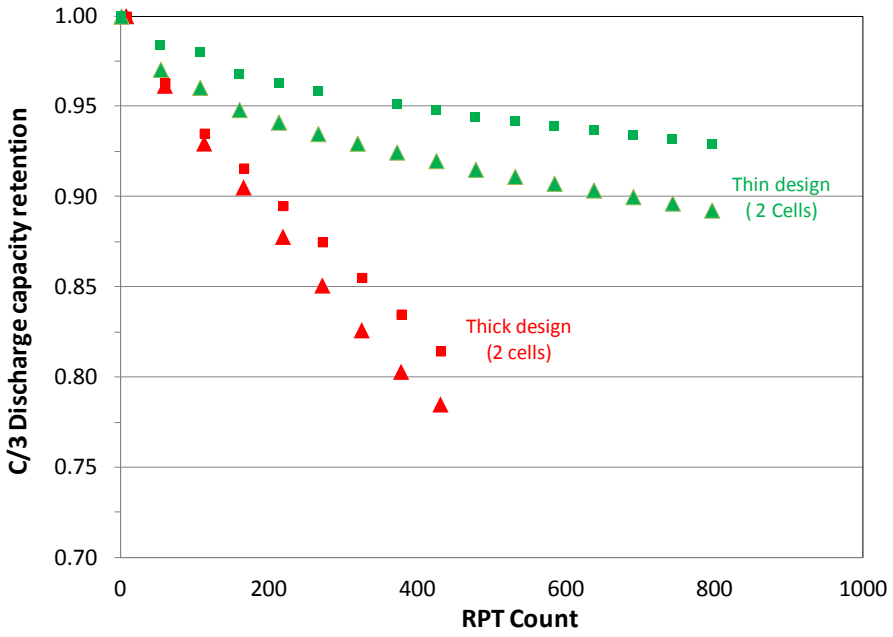


Equivalent to 13.5Wh (4.65V) in state of the art 18650 hardware!

Accomplishment - Cycle Life Improvement

18650 Data (EV cycling)

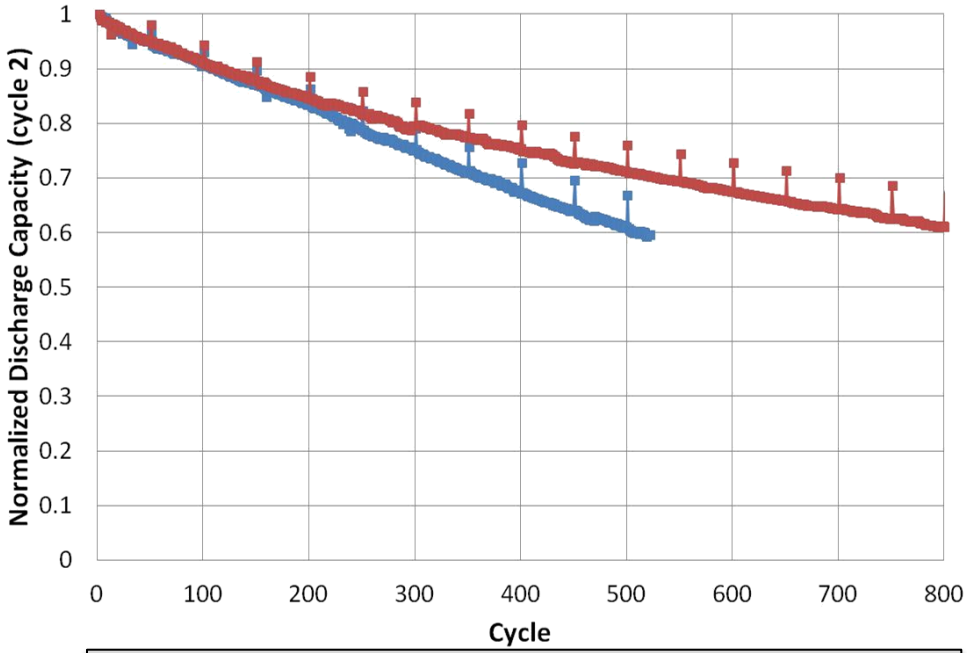
- *Anode: graphite*
- *Cathode: NMC 111*



~90% retention after 800 DST cycles

18650 Data (C/2 rate cycling)

- *Anode: 3M alloy / graphite composite*
- *Cathode: NMC 111*
- *Electrolyte: **A** & **B***



Electrolyte B gives ~50% improvement in cycle life over electrolyte A

Collaborations

- Dalhousie University (Jeff Dahn and Mark Obrovac)
  - *Technical discussion for most of lithium ion battery related areas.*
- Argonne National Lab (Ira Bloom and David Robertson)
  - *Testing procedure (EV protocol) discussion.*

Summary

- Demonstrated Materials Development with
  - *Viable High Energy NMC cathode*
  - *Stable voltage curve for Cathode*
  - *Reduced Si electrode thickness expansion*
  - *Rationale technique to study Si composite electrode*
- Demonstrated 18650 performance
  - *~40% energy improvement*
  - *Baseline material performance in EV protocol testing*
  - *Cycle life improvement with developed electrolyte*

Proposed Future Work

- Improve Cycle life
  - *Improve Si alloy design*
  - *Improve composite (Si alloy/Graphite) design*
  - *Optimize High Energy NMC design*
- Increased 18650 testing
  - *Develop improved electrolytes*
  - *Develop & test 18650 designs under range of conditions*
  - *Initiate EV protocol testing*